LSP 2.10 Davinci Linux VPFE Capture Driver

User's Guide

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Contents

1 **Introduction** 6
1.1 EVM Configuration for Video Capture 7
1.2 Supported Features 8
1.3 Constraints 8
2 **Driver Overview** 9
2.1 Driver Architecture 9
2.2 Design 10
2.2.1 Initialization 11
2.2.2 Opening and Closing of Driver 11
2.2.3 Buffer Management 11
2.2.4 Configuration and Control 13
2.2.5 IOCTLs Handling 16
2.2.6 ISR Handling 28
3 **Portability** 30
3.1 Decoders 30
3.1.1 Data Structures and API for Decoder Interface 30
3.1.2 Supported Decoders 33
3.1.3 Adding New Decoder Support 34
4 **User Interface** 35
4.1 API 35
4.2 Data Structures 35
4.2.1 CCDC Configuration 35
4.2.2 CCDC Control 35
4.2.3 MT9T001 Parameter Structure 36
4.2.4 MT9P031 Parameter Structure 36
4.2.5 TVP5146 Parameter Structure 37
4.2.6 TVP7002 Parameter Structure 37
4.2.7 Request Buffer Structure for V4L2 37
4.2.8 Buffer Structure for V4L2 38
4.2.9 Query Capability Structure for V4L2 39
4.2.10 Input Structure for V4L2 39
4.2.11 Standard Structure for V4L2 40
4.2.12 Format Description Structure for V4L2 40
4.2.13 Format Structure for V4L2 41
4.2.14 Query Control Structure for V4L2 41
4.2.15 Control Structure for V4L2 42
4.3 Enumerations and Defines 42
4.3.1 Possible Standards for Different Decoders 42
5 **Driver Files** 43
6 **Build and Installation** 44
6.1 Build Steps 44

6.2 Installation 45
7 Example Applications 46

List of Figures

1 Simplified Architecture of VPFE 6
2 DM365 EVM Configuration for Video Capture 7
3 Basic Architecture of the VPFE Capture Driver 9
4 VPFE Capture Driver Detailed Design 10
5 Interrupt Handling Timing Diagram 28
6 VPFE Capture Drivers Selection as a Static Module 44
7 VPFE Capture Drivers Selection as a Dynamic Module 44

List of Tables

1 Pixel Formats Supported by VIDIOC_ENUM_FMT 19
2 Parameter Adjustments 21
3 VPFE Capture Driver Files 43

LSP 2.10 Davinci Linux VPFE Capture Driver

1 Introduction

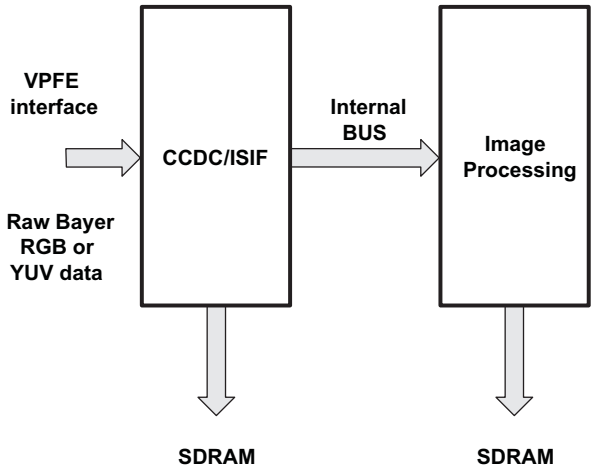
VPFE Capture driver is a V4L2 device driver for capturing video frames from a Raw Bayer RGB or Raw YUV data source.

VPFE Capture driver described in this document is applicable to following DaVinci SoCs:

- DM6446
- DM355
- DM365

A simplified architecture (simplified for the sake of describing the driver) of the Video Processing Front End (VPFE) as applicable to the driver is shown in Figure 1. Only functional IPs that are directly controlled by the VPFE capture driver is shown in the diagram. Please refer respective VPFE Hardware PRG for more details on the VPFE available on a particular SoC.

Figure 1. Simplified Architecture of VPFE



VPFE provides an input interface for external imaging peripherals such as image sensors, video decoders etc. VPFE can process Raw Bayer RGB data from an image sensor such as Micron's MT9T001 and convert to viewable formats such as UYVY using the image processing hardware in the VPFE. It can also process Raw YUV data from a video decoder device such as TVP5146 or TVP7002.

VPFE consists of two main blocks:

- **CCD controller (CCDC)**. This has been renamed to Image Sensor Interface (ISIF) in DM365 but refers to the same. This block pre-process input data before saving to SDRAM or passing it to the Image processing block. Pre-processing is applicable only for raw Bayer RGB data from a sensor. Examples of pre-processing includes defect pixel correction, a-law compression, color space conversion, data formatting etc.
- **Image Processing (IMP)**. This block is responsible for doing image tuning on a raw Bayer RGB data output from CCDC/ISIF or from SDRAM and upscale/downscale the output to a desired resolution. In DM6446, this block consists of Preview Engine and Resizer. More features have been added to VPFE in newer SoCs to help in image processing and the same is renamed to Image Pipe (IPIPE) in DM355 and DM365. Image processing unit has a pipeline of modules each of which modifies the image based on parameters configured in these modules.

Examples of image tuning modules include White Balance, Noise filter, RGB to RGB converter, Edge enhancement, Gamma Correction etc. Please refer VPFE hardware user guide for more details on these modules. Resizer hardware is used to upscale or downscale the image to a desired resolution. DM6446 has one Resizer output where as in DM355 and DM365, there are 2 Resizers acting on the same video input (RSZ-A & RSZ-B) there by producing 2 output resolutions. VPFE capture driver would require image processing unit to do image tuning and for upscale or downscale the image before being written to SDRAM. For chaining the image processing modules in the data path from CCDC/ISIF, IPIPE must be configured to work in continuous mode.

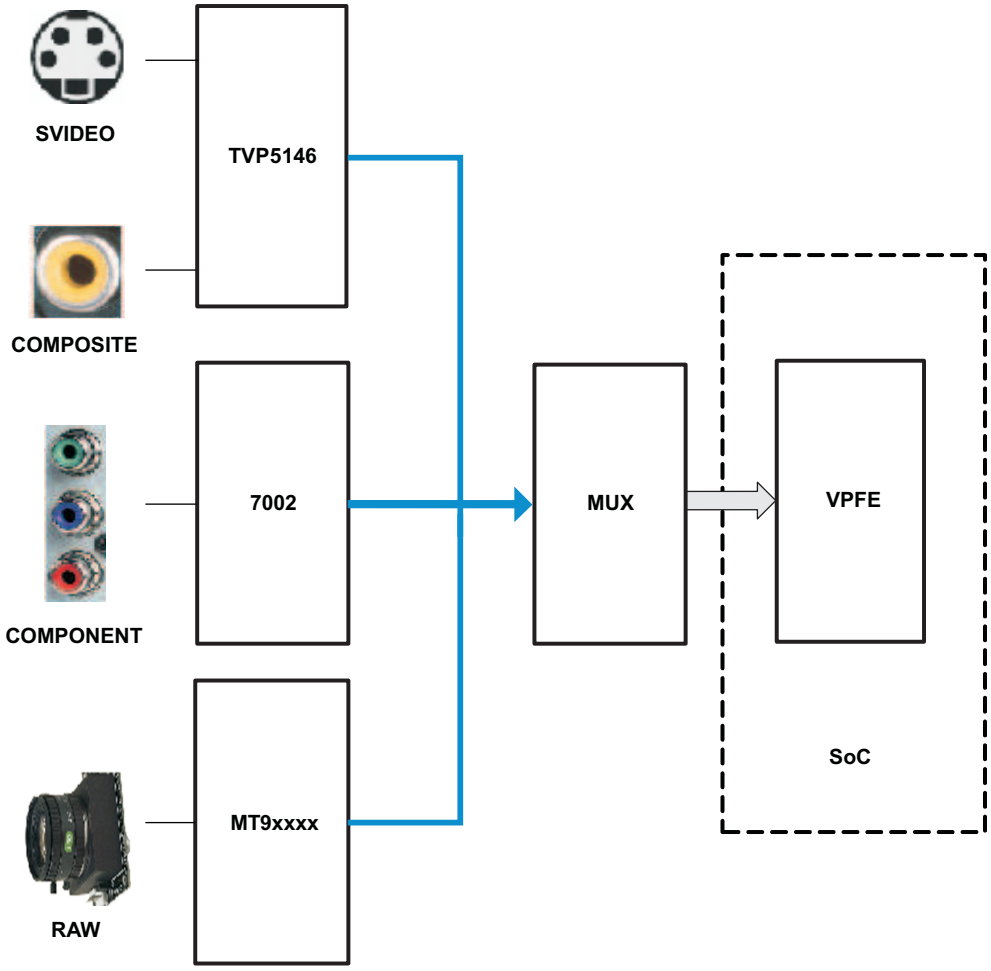
VPFE Capture driver can configure VPFE to output data from CCDC/ISIF or from the output of Resizer in Image Processing Module (Not available on DM6446).

1.1 EVM Configuration for Video Capture

Figure 2 shows the high level configuration of the DM365 EVM that enables video capture using VPFE. The EVM configuration of DM6446 and DM355 are similar except they do not have TVP7002 to do HD video capture. VPFE provides a Raw Bayer parallel interface as well as 8/16 bit YCbCr interface to connect a variety of video peripheral to do video capture. See the VPFE hardware PRG for the interface specifications. Outputs from various peripherals are multiplexed using CPLD. This allows for the driver to dynamically connect VPFE to one of the peripheral output to do video capture.

The VPFE capture driver uses this logic to allow dynamic switching of input on request from the application. The diagram also shows the label used by driver to name each of the input supported by the input peripherals. Note that RAW is the name used to represent the camera sensor input. Additional camera inputs are represented by RAW-1, RAW-2 etc.…

Figure 2. DM365 EVM Configuration for Video Capture



1.2 Supported Features

Following are the main features:

- The driver can be used statically or dynamically.
- Supports one video device (Video0).
- Supports single I/O instance and multiple control instances.
- Supports buffer access mechanism through memory mapping as well as user pointers.
- Supports dynamic switching among input interfaces and various resolutions with some necessary restrictions wherever applicable.
- Supports capture to SDRAM from CCDC or from Resizer (for DM355 & DM365).

1.3 Constraints

Following are the constraints for the Capture driver:

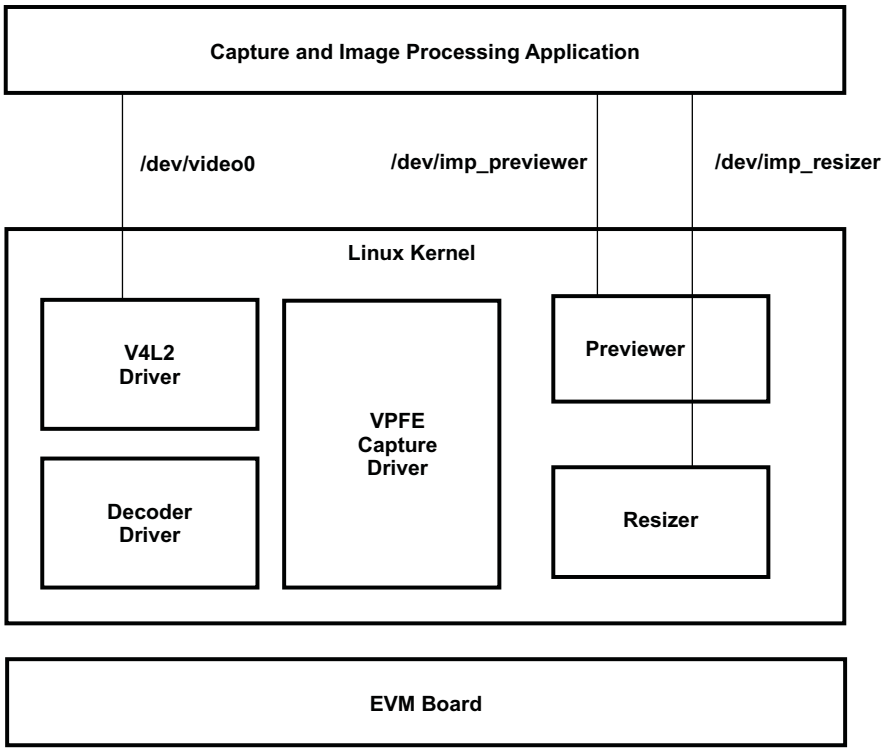
- Dynamic switching of resolution and dynamic switching of interfaces is not supported when streaming is on.
- VPFE input/output buffer addresses must be a multiple of 32.
- By default, the driver allocates three buffers for the device. The buffer size is 1920 x 1080 x 2 + 640 x 480 x 2.
- If the application is requesting the user pointer buffer exchange mechanism, then it must request a minimum of three buffers.
- If you have specified less than three and greater than zero buffers at the time of inserting the driver, the driver allocates three buffers. If you have specified zero buffers, the driver assumes the use of the user pointer buffer exchange mechanism.
- If you have specified the buffer size as less than the buffer size required to store an NTSC image at the time of the insertion of the driver, the driver assumes minimum buffer size.
- If you have specified an incorrect device_type at the time of the insertion of the driver, the driver assumes zero values for the device_type.
- In continuous mode, with interlaced scan input, only the second field of the input data is used for capture at Resizer and is scaled up by 2x to preserve the height. So in this mode, the video is de-interlaced at the driver and hence both fields are not available.

2 Driver Overview

2.1 Driver Architecture

Following block diagram shows basic architecture of the VPFE capture Driver.

Figure 3. Basic Architecture of the VPFE Capture Driver



VPFE Capture driver exposes the capabilities of the hardware to applications using the standard V4L2 interface. Applications will be able to use a V4L2 device (video0) to capture frames from a image sensor or video decoder connected to VPFE. There are two main data flow paths available in the driver.

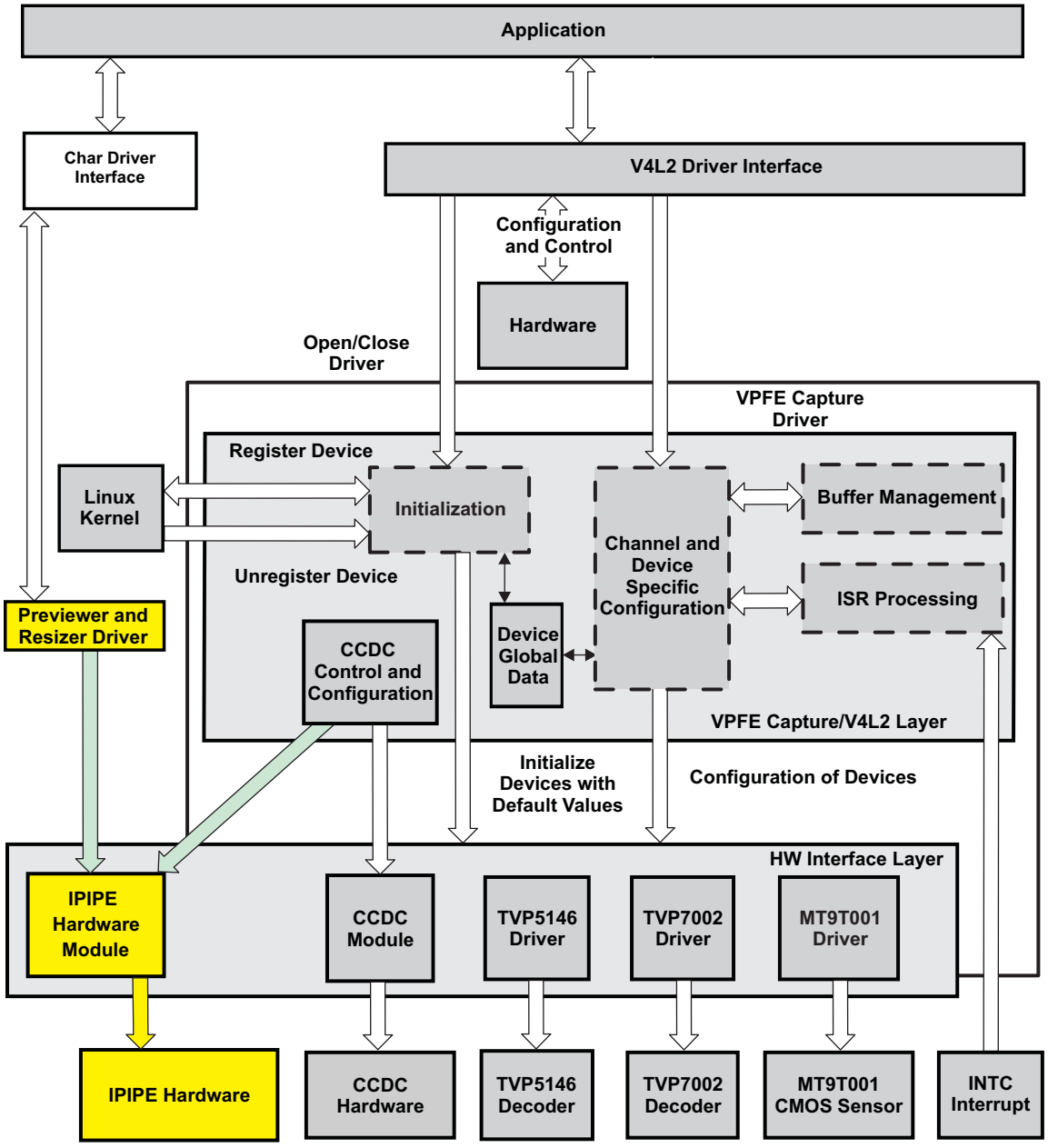
1. Input interface to SDRAM through CCDC. This path is available on all supported SoCs.
2. Input interface to CCDC to Image Processing Unit and then output from Resizer. This is available only on DM355 and DM365. The Resizer on these devices have two outputs: one full resolution image (RSZ-A) and another smaller resolution image (RSZ-B). Typically, this helps in previewing one image (usually of a smaller resolution) to a display device and the other (full resolution) for encoding. The Driver piggy backs the second image at the end of first image in the buffer when the same is de-queued from the device.

To support the data path 2, capture driver requires that the IPIPE & Resizer hardware are configured to operate in the continuous mode through the previewer and Resizer device. Previewer driver drives IPIPE and Resizer driver drives Resizer hardware respectively. Please refer Previewer/Resizer User Manual for details on these drivers. Once these hardware configuration is complete, Capture driver will be able to use it do on the fly (continuous mode) image tuning and scaling.

2.2 Design

Figure 4 shows the detailed design of the VPFE Capture Driver.

Figure 4. VPFE Capture Driver Detailed Design



2.2.1 Initialization

At initialization the driver does the following:

- Initializes the CCDC for the default configuration parameters
- Allocates vpfe_obj that holds channel configuration
- Allocates frame buffers
- Registers the driver and platform device

Upon probing, the following are done:

- Initialize the channel data structures
- Allocate video device and register video device with v4l2 framework

2.2.2 Opening and Closing of Driver

The device can be opened using open call from application with device name and mode of operation as parameters. Application can open the driver in either blocking mode or non-blocking mode. If the channel is opened in non-blocking mode, driver calls (call to DQBUF) will return to application without waiting for request completion.

During open(), driver also selects a decoder from the available decoders based on the bootargs and initialize the same. Using the default standard on the decoder, the channel parameters are configured. This also sets the channel initialized state if everything is successful.

The driver will support single I/O instance and multiple control instances of each of the channels.

The file descriptor with which VIDIOC_REQBUFS IOCTL is called, will become I/O instance. And rest will be control instances.

Application can simply call the close function with file handle to close a specific device. Application should close all the control channels before closing an I/O channel.

Note: When using data flow path 2 in the capture driver, make sure to open and configure the previewer and Resizer devices in continuous mode prior to opening the capture device.

```
/* call to open a video capture logical channel in blocking mode */
video0fd_blocking =open ("/dev/video0", O_RDWR);

/* call to open a video capture logical channel in non-blocking mode */
video0fd_nonblocking =open ("/dev/video0", O_RDWR | O_NONBLOCK);

/* closing of channels */
close (video0fd_blocking);
close (video0fd_nonblocking);
```

2.2.3 Buffer Management

The driver allows two different types of memory allocation modes:

- Driver buffer mode
- User buffer mode

For driver buffer mode, application can request memory from driver by calling VIDIOC_REQBUFS. In case of user buffer, application needs to allocate physically contiguous memory using some other mechanism in user space. In driver buffer mode, maximum number of buffers is limited to VIDEO_MAX_FRAME (defined in driver header files).

Here are the major steps to be performed by application for buffer allocation:

1. Allocating Memory

This IOCTL is used to allocate memory for frame buffers.

IOCTL: VIDIOC_REQBUFS.

It takes a pointer to instance of v4l2_requestbuffers structure as an argument.

The user can specify the buffer type (V4L2_BUF_TYPE_VIDEO_CAPTURE), number of buffers and memory type (V4L2_MEMORY_MMAP) at the time of buffer allocation.

The file descriptor which will call VIDIOC_REQBUFS IOCTL, will be considered as I/O instance.

Constraint: This IOCTL can be called only once from application.

Example:

```
/* structure to store buffer request parameters */
struct v4l2_requestbuffers reqbuf;

reqbuf.count = numbuffers;
reqbuf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
reqbuf.memory = V4L2_MEMORY_MMAP;

ret = IOCTL(fd , VIDIOC_REQBUFS, &reqbuf);
if(ret) {
        printf("cannot allocate memory\n");
        close(fd);
        return -1;
}
```

If data flow path 2 is used and Resizer output2 is also enabled, then make sure the frame buffer allocated should be large enough to hold both images (output1/RSZ-A and output2/RSZ-B). For MMAP, the kernel allocates memory to hold both outputs. For USERPTR, this is the responsibility of the application.

2. Getting Physical Address

This IOCTL is used to get Physical address of the allocated buffer.

IOCTL: VIDIOC_QUERYBUFS.

It takes a pointer to instance of v4l2_buffer structure as an argument.

User has to specify buffer type (V4L2_BUF_TYPE_VIDEO_CAPTURE), buffer index and memory type (V4L2_MEMORY_MMAP) at the time of querying.

Example:

```
/* allocate buffer by VIDIOC_REQBUFS */

/* structure to query the physical address of allocated buffer */
struct v4l2_buffer buffer;

buffer.index = 0; /* buffer index for querying -0 */
buffer. type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
buffer.memory = V4L2_MEMORY_MMAP;

if (IOCTL(fd, VIDIOC_QUERYBUF, &buffer) == -1) {
        printf("buffer query error.\n");
        close(fd);
        exit(-1);
}
```

The buffer.m.offset will contain the physical address returned from driver.

3. Mapping Kernel Space Address to User Space

Mapping of the kernel buffer to the user space can be done via mmap. User can pass buffer size and physical address of buffer for getting the user space address.

```
/* allocate buffer by VIDIOC_REQBUFS */

/* query the buffer using VIDIOC_QUERYBUF */

/* addr hold the user space address */
Int addr;
Addr = mmap(NULL, buffer.size,PROT_READ | PROT_WRITE, MAP_SHARED,
        fd, buffer.m.offset);
/* buffer.m.offset is same as returned from VIDIOC_QUERYBUF */
```

2.2.4 Configuration and Control

This block is responsible for configuring the CCDC and Image processing hardware for capture. Application configures and control the hardware using IOCTL calls. This is done prior to starting streaming on the device and de-queuing the frames. To configure the hardware to implement data flow path #1 and #2, the driver needs to configures CCDC and Image processing Unit (IPIPE and Resizer).

VPFE capture driver uses CCDC hw interface (defined ccdc_hw_if.h) to configure CCDC and use imp hw interface (defined in imp_hw_if.h) to configure IPIPE and Resizer.

2.2.4.1 CCDC Configuration

VPFE driver uses functions defined at the CCDC hw interface (ccdc_hw_if.h) to configure CCDC on a specific SoC. By using these interface functions, the CCDC module conceal the differences in the CCDC across different SoCs and provides an uniform way to configure the CCDC hardware for capture. Following are the functions available at the interface. To Support a new SoC, a CCDC module is developed that implements these functions. All of the CCDC modules are developed using this interface.

Example 1. CCDC Device Interface

```
/*
 * CCDC device interface
 */
struct ccdc_hw_interface {

    /* CCDC device name */
    char *name;

    /* Pointer to initialize function to initialize ccdc device */
    int (*initialize) (void);
    /* Set of functions pointers for control related functions.
     * Use queryctrl of decoder interface to check if it is a decoder
     * control id. If not passed to ccdc to process it
     */
    void (*enable) (int en);
    /* Pointer to function to enable or disable ccdc */
    u32 (*reset) (void);
    /* reset sbl. only for 6446 */
    void (*enable_out_to_sdram) (int en);
    /* Pointer to function to set hw frame type */
    int (*set_hw_if_type) (enum ccdc_hw_if_type iface);
    /* get interface parameters */
    int (*get_hw_if_params) (struct ccdc_hw_if_param *param);
    /* Set/Get parameters in CCDC */
    /* Pointer to function to set parameters. Used
     * for implementing VPFE_S_CCDC_PARAMS
     */
    int (*setparams) (void *params);
    /* Pointer to function to get parameter. Used
     * for implementing VPFE_G_CCDC_PARAMS
     */
    int (*getparams) (void *params);
    /* Pointer to function to configure ccdc */
    int (*configure) (void);

    /* Set of functions pointers for format related functions */
    /* Pointer to function to try format */
    int (*tryformat) (struct v4l2_pix_format *argp);
    /* Pointer to function to set buffer type */
    int (*set_buftype) (enum ccdc_buftype buf_type);
    /* Pointer to function to get buffer type */
    int (*get_buftype) (enum ccdc_buftype *buf_type);
    /* Pointer to function to set frame format */
    int (*set_frame_format) (enum ccdc_frmfmt frm_fmt);
    /* Pointer to function to get frame format */
    int (*get_frame_format) (enum ccdc_frmfmt *frm_fmt);
    /* Pointer to function to set buffer type */
    int (*get_pixelformat) (unsigned int *pixfmt);
    /* Pointer to function to get pixel format. Uses V4L2 type */
    int (*set_pixelformat) (unsigned int pixfmt);
```

Example 1. CCDC Device Interface (continued)

```
    /* Pointer to function to set image window */
    int (*set_image_window) (struct v4l2_rect *win);
    /* Pointer to function to set image window */
    int (*get_image_window) (struct v4l2_rect *win);
    /* Pointer to function to set line length */
    int (*set_line_length) (unsigned int len);
    /* Pointer to function to get line length */
    int (*get_line_length) (unsigned int *len);
    /* Pointer to function to set crop window */
    int (*setcropwindow) (struct v4l2_rect *win);
    /* Pointer to function to get crop window */
    int (*getcropwindow) (struct v4l2_rect *win);

    /* Query SoC control IDs */
    int (*queryctrl)(struct    v4l2_queryctrl *qctrl);
    /* Set SoC control */
    int (*setcontrol)(struct v4l2_control *ctrl);
    /* Get SoC control */
    int (*getcontrol)(struct v4l2_control *ctrl);
    /* Pointer to function to set current standard info */
    int (*setstd) (char *std);
    /* Pointer to function to get current standard info */
    int (*getstd_info) (struct ccdc_std_info *std_info);

    /* Pointer to function to set frame buffer address */
    void (*setfbaddr) (unsigned long addr);
    /* Pointer to function to get field id */
    int (*getfid) (void);
    /* Pointer to deinitialize function */
    int (*deinitialize) (void);
};
```

2.2.4.2 Image Processing Unit Configuration

Image processing exposes two interfaces (defined in imp_hw_interface.h) to configure the IPIPE and Resizer. One interface is used by previewer & Resizer driver. (See Previewer-Resizer Driver User manual for details). The other interface is used by VPFE capture driver to configure parameters like width, height, pixel format, resize ratio etc when user invokes ioctls. The IPIPE modules on DM355 and DM365 implements the interface functions. Following are the set of functions exposed by IPIPE module to vpfe capture driver.

Example 2. Functions Exposed by IPIPE to VPFE Capture Driver

```
struct imp_hw_interface {

    /* Name of the image processor hardware */
    char *name;


    /* update output buffer address for a channel
     * if config is NULL, the shared config is assumed
     * this is used only in single shot mode
     */
    int (*update_inbuf_address) (void *config, unsigned int address);
    /* update output buffer address for a channel
     * if config is NULL, the shared config is assumed
     */
    int (*update_outbuf1_address) (void *config, unsigned int address);
    /* update output buffer address for a channel
     * if config is NULL, the shared config is assumed
     */
    int (*update_outbuf2_address) (void *config, unsigned int address);
    /* enable or disable hw */
    void (*enable) (unsigned char en, void *config);
    /* enable or disable Resizer to allow frame by frame resize in
     * continuous mode
```

Example 2. Functions Exposed by IPIPE to VPFE Capture Driver (continued)

```
     */
    void (*enable_resize) (int en);
    /* setup hardware for processing. if config is NULL,
     * shared channel is assumed
     */
    int (*hw_setup) (struct device *dev, void *config);
    /* Get preview irq numbers */
    void (*get_preview_irq) (struct irq_numbers *irq);
    /* Get resize irq numbers */
    void (*get_rsz_irq) (struct irq_numbers *irq);
    /* Get configuration state of Resizer in continuous mode */
    unsigned int (*get_resizer_config_state) (void);
    /* Get configuration state of previewer in continuous mode */
    unsigned int (*get_previewer_config_state) (void);

    /* Below APIs assume we are using shared configuration since
     * oper mode is continuous. These are called from vpfe capture driver
     */
    /* Set the input crop window at the IMP interface and IMP */
    int (*set_input_win) (struct imp_window *win);
    /* Get current input crop window param at the IMP */
    int (*get_input_win) (struct imp_window *win);
    /* Set interface parameter at IPIPEIF. Only valid for DM360 */
    int (*set_hw_if_param) (struct ccdc_hw_if_param *param);
    /* Set input pixel format */
    int (*set_in_pixel_format) (enum imp_pix_formats pix_fmt);
    /* set output pixel format */
    int (*set_out_pixel_format) (enum imp_pix_formats pix_fmt);
    /* 0 - interleaved, 1 - field seperated */
    int (*set_buftype) (unsigned char buf_type);
    /* 0 - interlaced, 1 - progressive */
    int (*set_frame_format) (unsigned char frm_fmt);
    /* Set the output window at the IMP, output selection
     * done by out_sel. 0 - output 1 and 1 - output 2
     */
    int (*set_output_win) (struct imp_window *win);
    /* Get output enable/disable status */
    int (*get_output_state) (unsigned char out_sel);
    /* Get output line lenght */
    int (*get_line_length) (unsigned char out_sel);
    /* Get the output image height */
    int (*get_image_height) (unsigned char out_sel);
    /* Get current output window param at the IMP */
    int (*get_output_win) (struct imp_window *win);
    /* get maximum output width of rsz-a or rsz_b*/
    int (*get_max_output_width) (int rsz);
    /* get maximum output height of rsa-a or rsz-b */
    int (*get_max_output_height) (int rsz);
};
```

2.2.5 IOCTLs Handling

2.2.5.1 Query Capabilities

This IOCTL is used to identify kernel devices compatible with V4L2 specification and to obtain information about individual hardware capabilities.

IOCTL: VIDIOC_QUERYCAP

Capabilities can be like video capture (V4L2_CAP_VIDEO_CAPTURE) or streaming (V4L2_CAP_STREAMING) capabilities.

It takes pointer to v4l2_capability structure as an argument. Capabilities can be accessed by capabilities field of v4l2_capability structure.

Example:

```
struct v4l2_capability capability;
ret = IOCTL(fd, VIDIOC_QUERYCAP, &capability);
if(ret) {
        printf("Cannot do QUERYCAP\n");
        return -1;
}
if(capability.capabilities & V4L2_CAP_VIDEO_CAPTURE) {
        printf("Capture capability is supported\n");
}
if(capability.capabilities & V4L2_CAP_STREAMING) {
        printf("Streaming is supported\n");
}
```

2.2.5.2 Input Enumeration

This IOCTL is used to enumerate the information of available inputs (analog interface).

IOCTL: VIDIOC_ENUMINPUT

It includes information like name of input type, supported standards for that input type.

Application will provide the index number for which it wants the information, as part of v4l2_input structure.

Index with value zero indicates first input type of first decoder that has been registered at the time of module insertion, and after possible inputs for first decoder, next index from application will be mapped to first input of second decoder, and so on.

That is, if the first registered decoder is TVP5146 and the second is MT9T031, and both are supporting one type of input; then if the application will pass 0 as an input index, it will enumerate the input of TVP5146 and for input index 1, it will enumerate the input of MT9T031.

The following are the names used to represent various inputs to the driver:

TVP5146	COMPOSITE and SVIDEO
TVP7002	COMPONENT
MT9T031/MT9T001	RAW
MT9P031	RAW-1

Example:

```
struct v4l2_input input;
i = 0;
while(1) {
      input.index = i;
      ret = IOCTL(fd, VIDIOC_ENUMINPUT,&input);
      if(ret) {
           break;
      }
printf("name = %s\n",input.name);
      printf("std =  %x\n",(unsigned long)input.std);
      i++;
}
```

2.2.5.3 Set Input

This IOCTL is used to set input type (analog interface type).

IOCTL: VIDIOC_S_INPUT

In order to accomplish this, driver will de-initialize the current decoder and initialize the decoder for which input index is provided. Application will provide the index number as an argument. Index with value zero indicates first input type of first decoder that has been registered at the time of module insertion, and after possible inputs for first decoder, next index from application will be mapped to first input of second decoder, and so on.

That is, if the first registered decoder is TVP5146 and the second is MT9T031, and both are supporting one type of input; then if the application will pass 0 as an input index, it will enumerate the input of TVP5146 and for input index 1, it will enumerate the input of MT9T001.

Example:

```
int index = 1;
ret = IOCTL(fd, VIDIOC_S_INPUT, &index);
if(ret) {
      perror("VIDIOC_S_INPUT\n");
      close(fd);
      return -1;
}
```

2.2.5.4 Get Input

This IOCTL is used to get input type (analog interface type).

IOCTL: VIDIOC_G_INPUT

It will call current video decoder's getinput function to get the current input used by the capture driver.

Application will provide the index number as an output argument. In this IOCTL call, parameters of current decoder will be reset to default value. So this IOCTL should be called before doing any modification to the default parameters.

Example:

```
int input;
ret = IOCTL(fd, VIDIOC_G_INPUT, &input);
if(ret) {
      perror("VIDIOC_G_INPUT\n");
      close(fd);
      return -1;
}
```

2.2.5.5 Standard Enumeration

This IOCTL is used to enumerate the information regarding video standards, which are possible for the current input of current decoder.

IOCTL: VIDIOC_ENUMSTD

It provides information like standard name, standard id defined at V4L2 header files (some new standards are added in respective decoder header files, which were not available in standard V4L2 header files.), and numerator and denominator values for frame period and frame lines.

It takes index as an argument as a part of v4l2_standard structure. If index value exceeds the number of standards supported by current decoder, it will give error.

Example:

```
struct v4l2_standard standard;
i = 0;
while(1) {
      standard.index = i;
      ret = ioctl(fd, VIDIOC_ENUMSTD,&standard);
      if(ret) {
            break;
      }
```

```
printf("name = %s\n",std.name);
      printf("std = %x\n",(unsigned long)std.id);
      printf("framelines = %d\n",std.framelines);
      printf("numerator = %d\n",std.frameperiod.numerator);
      printf("denominator = %d\n",std.frameperiod.denominator);
      i++;
}
```

2.2.5.6 Example Standard Detection

This IOCTL is used to detect the current video standard set in current decoder.

IOCTL: VIDIOC_QUERYSTD

It provides information like standard name, standard id defined at V4L2 header files (some new standards are added in respective decoder header files, which were not available in standard V4L2 header files.), and numerator and denominator values for frame period and frame lines.

Driver will call current decoder's function internally (which has been initialized) to detect the current standard set in hardware. Support of this IOCTL depends on decoder device, whether it can detect standard or not.

That is, MT9Txxx decoder has no mechanism to detect the standard. It takes Pointer to v4l2_std_id instance as an output argument. Standard ids are defined at V4L2 header files (some new standards are added in respective decoder header files, which were not available in standard V4L2 header files.)

Example:

```
v4l2_std_id std;
ret = ioctl(fd, VIDIOC_QUERYSTD, &std);
if(ret) {
      perror("G_INPUT\n");
      close(fd);
      return -1;
}
printf("std = %x\n", (unsigned long)std);
```

2.2.5.7 Set Standard

This IOCTL is used to set the standard in current decoder.

IOCTL: VIDIOC_S_STD

If the standard is not supported by current decoder, driver will give error. It takes Pointer to v4l2_std_id instance as an input argument.

Standard ids are defined at V4L2 header files (some new standards are added in respective decoder header files, which were not available in standard V4L2 header files.)

Example:

```
v4l2_std_id std = V4L2_STD_525_60;
ret = IOCTL(fd, VIDIOC_S_STD, &std);
if(ret) {
      perror("S_STD\n");
      close(fd);
      return -1;
}
```

2.2.5.8 Get Standard

This IOCTL is used to get the current standard in current decoder.

IOCTL: VIDIOC_G_STD

It takes Pointer to v4l2_std_id instance as an output argument.

Standard ids are defined at V4L2 header files (some new standards are added in respective decoder header files, which were not available in standard V4L2 header files.)

Example:

```
v4l2_std_id std;
ret = ioctl(fd, VIDIOC_G_STD, &std);
if(ret) {
      perror("G_STD\n");
      close(fd);
      return -1;
}
printf("std = %x\n", (unsigned long)std);
```

2.2.5.9 Format Enumeration

This IOCTL is used to enumerate the information of format (width, heght, bytesperline, image size, pixel format etc.) those are supported by current decoder.

IOCTL: VIDIOC_ENUM_FMT

As per current decoder's interface type (INTERFACE_TYPE_RAW, INTERFACE_TYPE_BT656, INTERFACE_TYPE_BT1120), it will fill the structure.

It will take pointer to instance of v4l2_fmtdesc structure as an output parameter.

If data flow path 2 is used, it will enumerate pixel format that are available at the output of the Resizer.

Following are the pixel formats supported…

Table 1. Pixel Formats Supported by VIDIOC_ENUM_FMT(1)

SOC	Raw Bayer Data Input	Raw YCbCr (YUV) Input
DM6446	V4L2_PIX_FMT_SBGGR16 (Raw Mode – Bayer Pattern GrRBGb – 16 bit) V4L2_PIX_FMT_SBGGR8 (Raw Mode – Bayer Pattern GrRBGb – 8 bit). This is A-Law compressed.	V4L2_PIX_FMT_UYVY V4L2_PIX_FMT_YUYV
DM355	V4L2_PIX_FMT_SBGGR16 (Raw Mode – Bayer Pattern GrRBGb – 16 bit) V4L2_PIX_FMT_SBGGR8 (Raw Mode – Bayer Pattern GrRBGb – 8 bit). This is A-Law compressed. *V4L2_PIX_FMT_UYVY*	V4L2_PIX_FMT_UYVY V4L2_PIX_FMT_YUYV
DM365	V4L2_PIX_FMT_SBGGR16 (Raw Mode – Bayer Pattern GrRBGb – 16 bit) V4L2_PIX_FMT_SBGGR8 (Raw Mode – Bayer Pattern GrRBGb – 8 bit). This is A-Law compressed or DPCM compressed based on compression algorithm selected in CCDC configuration. *V4L2_PIX_FMT_UYVY* *V4L2_PIX_FMT_NV12*	V4L2_PIX_FMT_UYVY V4L2_PIX_FMT_YUYV *V4L2_PIX_FMT_NV12*

(1) Pixel formats shown in italics require data flow path 2 to be configured in the driver.

Example:

```
struct v4l2_fmtdesc fmt;
i = 0;
while(1) {
      fmt.index = i;
      ret = ioctl(fd, VIDIOC_ENUM_FMT,& fmt);
      if(ret) {
            break;
      }
      printf("description = %s\n",fmt.description);
      if(fmt.type == V4L2_BUF_TYPE_VIDEO_CAPTURE)
            printf("Video capture type\n");
      if(fmt.pixelformat == V4L2_PIX_FMT_UYVY)
            printf("V4L2_PIX_FMT_UYVY\n");
      i++;
}
```

2.2.5.10 Set Format

This IOCTL is used to set format for current decoder.

IOCTL: VIDIOC_S_FMT

Driver will validate the input parameters. Driver will return an error if parameters are not valid otherwise driver will configure these parameters.

It will take pointer to instance of v4l2_format structure as an input parameter. Format type will be set as V4L2_BUF_TYPE_VIDEO_CAPTURE for capture driver. v4l2_format structure contains parameters like Pixel format, size of image, bytes per line, field type. Driver will adjust the width and height to match with the hardware.

Note: If the preview-Resizer is configured in the continuous mode, calling VIDIOC_S_FMT IOCTL with a pixel format marked italic in Table 1 will use data flow path 2 (i.e data is output from Resizer). In this mode, when capturing interlaced video, only second field is captured to buffer and is scaled up by 2 to get the required height. So the resulting video is de-interlaced. This mean real interlaced capture is not supported in continuous mode.

Examples:

For using MMAP:

```
struct v4l2_format fmt;
memset(&fmt, 0, sizeof(fmt));
fmt.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
fmt.fmt.pix.pixelformat = V4L2_PIX_FMT_UYVY;
fmt.fmt.pix.width = 720;
fmt.fmt.pix.height = 480;
fmt.fmt.pix.field = V4L2_FIELD_INTERLACED;
ret = ioctl(fd, VIDIOC_S_FMT, &fmt);
if(ret) {
      perror("VIDIOC_S_FMT\n");
      close(fd);
      return -1;
}
```

Note: When using the MMAP based buffer exchange, the application fills in the width, height, pixel format and field. The driver calculates bytesperline and sizeimage, and returns the same to the application.

For using USERPTR:

```
struct v4l2_format fmt;
memset(&fmt, 0, sizeof(fmt));
fmt.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
fmt.fmt.pix.pixelformat = V4L2_PIX_FMT_UYVY;
fmt.fmt.pix.bytesperline = 720*2; // adjust this to be multiple of 32
fmt.fmt.pix.sizeimage = fmt.fmt.pix.bytesperline * 480;
/* Driver calculates width and height based on the above */
fmt.fmt.pix.field = V4L2_FIELD_INTERLACED;
ret = ioctl(fd, VIDIOC_S_FMT, &fmt);
if(ret) {
      perror("VIDIOC_S_FMT\n");
      close(fd);
      return -1;
}
```

Note: When using the USERPTR based buffer exchange, the application fills in bytesperline, sizeimage, pixel format and field. The driver calculates the width and height, and returns the same to the application.

The driver makes adjusts the parameters as follows:

Table 2. Parameter Adjustments

Parameter	Description
height	Minimum height is 1 line for progressive scan and 2 lines for interlaced scan. Maximum height is active lines of the standard selected (for data path 1) or height of QXGA resolution (1536 lines for data flow path 2) .
width	Minimum width is 32/bpp (bytes per pixel). Maximum width is maximum active pixels of the standard selected (for data flow path 1) or line size of the IPIPE (1344 pixels for DM355 or 2176 for DM365).
bytesperline	Multiple of 32

2.2.5.11 Get Format

This IOCTL is used to get format for current decoder.

IOCTL: VIDIOC_G_FMT

Driver will provide format parameters in the structure pointer passed as an argument.

It will take pointer to instance of v4l2_format structure as an input parameter. Format type will be set as V4L2_BUF_TYPE_VIDEO_CAPTURE for capture driver. v4l2_format structure contains parameters like Pixel format, size of image, bytes per line, field type.

Example:

```
struct v4l2_format fmt;
fmt.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
ret = IOCTL(fd, VIDIOC_G_FMT, &fmt);
if(ret) {
      perror("VIDIOC_G_FMT\n");
      close(fd);
      return -1;
}
```

2.2.5.12 Try Format

This IOCTL is used to validate the format for current decoder.

IOCTL: VIDIOC_TRY_FMT

Driver will adjust the parameter as required by the hardware.

It will take pointer to instance of v4l2_format structure as an input parameter.

Format type will be set as V4L2_BUF_TYPE_VIDEO_CAPTURE for capture driver. v4l2_format structure contains parameters like Pixel format, size of image, bytes per line, field type.

Example:

```
struct v4l2_format fmt;
fmt.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
fmt.fmt.pix.pixelformat = V4L2_PIX_FMT_UYVY;
fmt.fmt.pix.width = 720;
fmt.fmt.pix.height = 480;
fmt.fmt.pix.field = V4L2_FIELD_INTERLACED;
ret = IOCTL(fd, VIDIOC_TRY_FMT, &fmt);
if(ret) {
      perror("VIDIOC_TRY_FMT \n");
      close(fd);
      return -1;
}
```

Parameters are adjusted by driver as given in Table 2.

2.2.5.13 Set Stream Parameters

This IOCTL is used to change the fps from 60 to 30 for 720P@60fps capture from TVP7002. This is only added as a work around to support 720P@30fps.

IOCTL: VIDIOC_S_PARM

Example:

```
struct v4l2_streamparm param;
param.type =  V4L2_BUF_TYPE_VIDEO_CAPTURE;
param.parm.capture.timeperframe.numerator = 1;
param.parm.capture.timeperframe.denominator = 30;
ret = IOCTL(fd, VIDIOC_S_PARM,&param);
if(ret) {
      perror("VIDIOC_S_PARM \n");
      close(fd);
      return -1;
}
```

2.2.5.14 Get Stream Parameters

This IOCTL is used to get the current stream params when doing capture from TVP7002. This is only added as a work around to support 720P@30fps.

IOCTL: VIDIOC_G_PARM

Example:

```
struct v4l2_streamparm param;
param.type =  V4L2_BUF_TYPE_VIDEO_CAPTURE;
param.parm.capture.timeperframe.numerator = 1;
param.parm.capture.timeperframe.denominator = 30;
ret = IOCTL(fd, VIDIOC_G_PARM,&param);
if(ret) {
      perror("VIDIOC_G_PARM \n");
      close(fd);
      return -1;
}
printf("parm.numerator = %d\n",
        param.parm.capture.timeperframe.numerator);
printf("parm.denominator = %d\n",
        param.parm.capture.timeperframe.denominator);
```

2.2.5.15 Query Control

This IOCTL is used to get the information of control commands supported by current decoder.

IOCTL: VIDIOC_QUERYCTRL

Driver will fill Id member in this structure, with the control id defined in V4L2 header file, for which information is needed.

If the control command specified by Id is not supported in current decoder, driver will return an error.

It will take pointer to instance of v4l2_queryctrl structure as an output parameter.

Example:

```
struct v4l2_queryctrl ctrl;
ctrl.id =  V4L2_CID_GAIN;
ret = IOCTL(fd, VIDIOC_QUERYCTRL,&ctrl);
if(ret) {
      perror("VIDIOC_QUERYCTRL \n");
      close(fd);
      return -1;
}
printf("name = %s\n",ctrl.name);
printf("min = %d max = %d step = %d default = %d\n",
              ctrl.minimum, ctrl.maximum, ctrl.step, ctrl.default_value);
```

2.2.5.16 Set Control

This IOCTL is used to set the value for particular control in current decoder.

IOCTL: VIDIOC_S_CTRL

If the control command specified by Id is not supported in current decoder, driver will return an error. It will take pointer to instance of v4l2_control structure as an input parameter.

Example:

```
struct v4l2_control ctrl;
ctrl.id = V4L2_CID_GAIN;
ctrl.value = 5;
ret = IOCTL(fd, VIDIOC_S_CTRL, &ctrl);
if(ret) {
      perror("VIDIOC_S_CTRL\n");
      close(fd);
      return -1;
}
```

2.2.5.17 Get Control

This IOCTL is used to get the value for particular control in current decoder.

IOCTL: VIDIOC_G_CTRL

If the control command specified by Id is not supported in current decoder, driver will return an error. It will take pointer to instance of v4l2_control structure as an output parameter.

Example:

```
v4l2_std_id ctrl;
ret = IOCTL(fd, VIDIOC_G_CTRL, &ctrl);
if(ret) {
      perror("VIDIOC_G_CTRL \n");
      close(fd);
      return -1;
}
```

2.2.5.18 Queue Buffer

This IOCTL is used to enqueue the buffer in buffer queue.

IOCTL: VIDIOC_QBUF

Application has to specify buffer type (V4L2_BUF_TYPE_VIDEO_CAPTURE), buffer index and memory type (V4L2_MEMORY_MMAP or V4L2_MEMORY_USERPTR) at the time of queuing.

If this IOCTL is called with the file descriptor, with which VIDIOC_REQBUFS is not been done, driver will return an error.

Driver will enqueue buffer, if buffer queue is not empty. If queue is empty then driver will directly write buffer address to hardware registers.

It will take pointer to instance of v4l2_ buffer structure as an input parameter.

When data flow path 2 is used, there are two output images available in the buffer. First output image size is calculated based on width, height and pixel format set through S_FMT. Second output image from RSZ-B is available at the end of first output image. So its offset is sizeimage reported by driver in S_FMT adjusted to 32-byte boundary as follows:

- Offset of second output image in the de-queued buffer is calculated as `round32(width*height*bpp)`. For VGA with UYVY pixel format used for first output, this is `round32(640*480*2)`. That is, Offset is 614400.
- Offset of C-plane in the buffer for pixel format NV12 is calculated as `round32(width*height)`. For VGA, with UYVY pixel format, this is `round32(640*480)`. That is, Offset is 307200 bytes.

Examples:

```
struct v4l2_buffer buf;
buf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
buf.memory = V4L2_MEMORY_MMAP;
buf.index = 0;
ret = IOCTL(fd, VIDIOC_QBUF, &buf);
if(ret) {
      perror("VIDIOC_QBUF\n");
      close(fd);
      return -1;
}
```

Or

```
struct v4l2_buffer buf;
buf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
buf.memory = V4L2_MEMORY_USERPTR;
buf.index = 0;
/* length of the buffer. Calculated based on CCDC/RSZ-A output
 * image size that is reported by driver in S_FMT sizeimage. Second
 * output(RSZ-B output)image size is equal to
 * width * height * bpp. these parameters
 * are set in Resizer device for output2. bpp depends on pixel format
 * set in output2 structure.
 */
buf.length = first output image size + (second output image size)
ret = ioctl(fd, VIDIOC_QBUF, &buf);
if(ret) {
      perror("VIDIOC_QBUF\n");
      close(fd);
      return -1;
}
```

2.2.5.19 Dequeue Buffer

This IOCTL is used to dequeue the buffer in buffer queue.

IOCTL: VIDIOC_DQBUF

Application has to specify buffer type (V4L2_BUF_TYPE_VIDEO_CAPTURE) and memory type (V4L2_MEMORY_MMAP or V4L2_MEMORY_USERPTR) at the time of dequeueing.

If this IOCTL is called with the file descriptor, with which VIDIOC_REQBUFS is not been done, driver will return an error.

Driver will enqueue buffer, if buffer queue is not empty.

If channel is opened in non blocking mode, this IOCTL call will return immediately if there is no buffer in queue.

It will take pointer to instance of v4l2_ buffer structure as an output parameter.

Example:

```
struct v4l2_buffer buf;
buf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
buf.type = V4L2_MEMORY_MMAP;
ret = IOCTL(fd, VIDIOC_DQBUF, &buf);
if(ret) {
      perror("VIDIOC_DQBUF\n");
      close(fd);
      return -1;
}
```

2.2.5.20 Stream On

This IOCTL is used to start video capture functionality.

IOCTL: VIDIOC_STREAMON

If this IOCTL is called with the file descriptor, with which VIDIOC_REQBUFS is not been done, driver will return an error.

If streaming is already started, this IOCTL call will return an error.

Example:

```
ret = IOCTL(fd, VIDIOC_STREAMON, NULL);
if(ret) {
      perror("VIDIOC_STREAMON \n");
      close(fd);
      return -1;
}
```

2.2.5.21 Stream Off

This IOCTL is used to stop video capture functionality.

IOCTL: VIDIOC_STREAMOFF

If this IOCTL is called with the file descriptor, with which VIDIOC_REQBUFS is not been done, driver will return an error.

If streaming is yet not started, this IOCTL call will return an error.

Example:

```
ret = IOCTL(fd, VIDIOC_STREAMOFF, NULL);
if(ret) {
      perror("VIDIOC_STREAMOFF \n");
      close(fd);
      return -1;
}
```

2.2.5.22 Set Priority

This IOCTL is used to set priority for file descriptor.

IOCTL: VIDIOC_S_PRIORITY

It will take pointer to instance of v4l2_priority structure as an intput parameter.

Example:

```
enum v4l2_priority priority = V4L2_PRIORITY_DEFAULT;
ret = IOCTL(fd, VIDIOC_S_PRIORITY, &priority);
if(ret) {
      perror("VIDIOC_S_PRIORITY\n");
      close(fd);
      return -1;
}
```

2.2.5.23 Get Priority

This IOCTL is used to get priority for file descriptor.

IOCTL: VIDIOC_G_PRIORITY

It will take pointer to instance of v4l2_priority structure as an output parameter.

Example:

```
enum v4l2_priority priority;
ret = IOCTL(fd, VIDIOC_G_PRIORITY, &priority);
if(ret) {
      perror("VIDIOC_G_PRIORITY\n");
      close(fd);
      return -1;
}
If(priority == V4L2_PRIORITY_DEFAULT)
      Printf("Default Priority\n");
```

2.2.5.24 Get Decoder Parameters

This IOCTL is used to get parameters of current decoder which are specific to respective decoder and can not be got with v4l2 ioctls.

IOCTL: VPFE_CMD_G_DECODER_PARAMS

It takes void* as an output argument which ultimately points to the structure to the decoder set_params structure instance.

Example:

```
/* consider that TVP7002 is the current decoder */
tvp7002_params params;
ret = IOCTL(fd, VPFE_CMD_G_DECODER_PARAMS, &params);
if(ret) {
      perror("VPFE_CMD_G_DECODER_PARAMS \n");
      close(fd);
      return -1;
}
```

2.2.5.25 Set Decoder Parameters

This IOCTL is used to set parameters of current decoder which are specific to respective decoder and can not be set with v4l2 ioctls.

IOCTL: VPIF_CMD_S_DECODER_PARAMS

It takes void* as an output argument which ultimately points to the structure to the decoder set_params structure instance.

Example:

```
/* consider that TVP7002 is the current decoder */
tvp7002_params params;
ret = IOCTL(fd, VPFE_CMD_S_DECODER_PARAMS, &params);
if(ret) {
      perror("VPFE_CMD_G_DECODER_PARAMS \n");
      close(fd);
      return -1;
}
```

2.2.5.26 Set CCDC Parameters

This IOCTL is used to set CCDC parameters.

IOCTL: VPFE_S_CCDC_PARAMS

It takes void* as an input argument which ultimately points to the ccdc_param structure instance.

Example:

```
struct ccdc_param params; // initialize the CCDC parameters.
ret = IOCTL(fd, VPFE_S_CCDC_PARAMS, &params);
if(ret) {
      perror("VPFE_S_CCDC_PARAMS\n");
      close(fd);
      return -1;
}
```

2.2.5.27 Get CCDC Parameters

This IOCTL is used to get CCDC parameters.

IOCTL: VPFE_G_CCDC_PARAMS

It takes void* as an output argument which ultimately points to the ccdc_param structure instance.

Example:

```
struct ccdc_param params;
ret = IOCTL(fd, VPFE_G_CCDC_PARAMS, &params);
if(ret) {
      perror("VPFE_G_CCDC_PARAMS\n");
      close(fd);
      return -1;
}
```

2.2.5.28 Configure TVP 5146 Parameters

Replaced with Get/Set decoder parameters as shown in Section 2.2.5.24 and Section 2.2.5.25.

2.2.5.29 Set MT9T001 Parameters

This IOCTL is for backward compatibility. This calls setparam() call from MT9T001/MT9T031 driver if it is the current decoder.

IOCTL: VPFE_CMD_S_MT9T001_PARAMS

Example:

```
/* consider that MT9T001.MT9T031 is the current decoder */
mt9t001_params params; // initialize the mt9t001 parameters.
ret = IOCTL(fd, VPFE_CMD_S_MT9T001_PARAMS, &params);
if(ret) {
      perror("VPFE_CMD_S_MT9T001_PARAMS\n");
      close(fd);
      return -1;
}
```

2.2.5.30 Get MT9T001 Parameters

This IOCTL is for backward compatibility. Driver provides functionality to fetch parameters of MT9T001/MT9T031, if it is a current decoder.

IOCTL: VPFE_CMD_G_MT9T001_PARAMS

It takes void* as an output argument which ultimately points to the structure to the mt9t001_params structure instance.

Example:

```
/* consider that MT9T001 is the current decoder */
mt9t001_params params;
ret = IOCTL(fd, VPFE_CMD_G_MT9T001_PARAMS, &params);
if(ret) {
      perror("VPFE_CMD_G_MT9T001_PARAMS\n");
      close(fd);
      return -1;
}
```

2.2.6 ISR Handling

CCDC has three interrupt registers :- VINT0, VINT1 and VINT2. They can be programmed to occur at any instance relative to VD signal from the hardware. In the VPFE driver, interrupts are used to mark a frame capture is complete and schedule next frame for capture and also release the frame to application. Different interrupts are used for this purpose based on whether the capture happens from output of CCDC or output of Resizer.

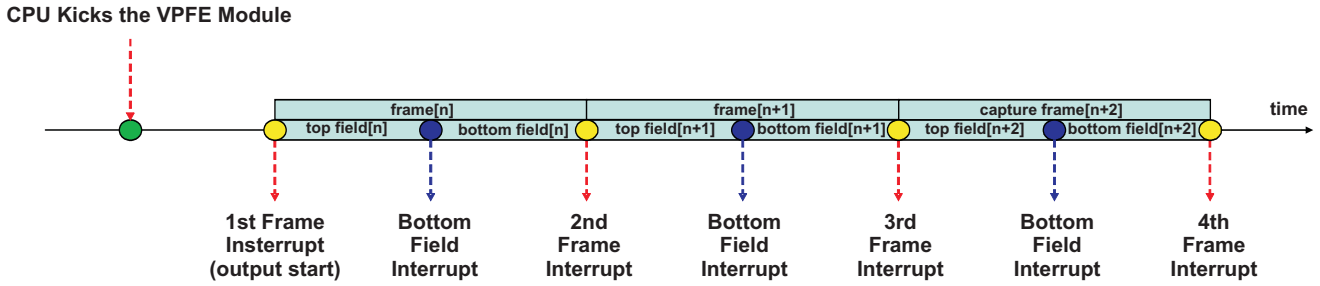
2.2.6.1 Output From CCDC (Data Flow Path 1)

For this, VINT0 is configured to occur at VD. This will generate the frame and field interrupts to align with the frame and field start. VINT1 is configured to occur at midway in the frame.

For interlaced scan, frame interrupt coincides with the top field (first field) interrupt and bottom field (second field) interrupt happens at the middle of frame interrupts. For progressive scan, only frame interrupts happens. VINT1 is configured to happens at midway between frame interrupts for progressive scans.

Figure 5 illustrates the relationship between the first interrupt and incoming data in case of frame interrupt.

Figure 5. Interrupt Handling Timing Diagram



This is the sequence:

1. VPFE Capture driver attaches, vpfe_isr() routine to process VINT0 and vdint1_isr() to process VINT1 interrupts.
2. When application call STREAMON IOCTL, vpfe driver calls configure() function from the ccdc hw interface to configure CCDC. As part of this, CCDC module configures VINT0 and VINT1 (if progressive scan).
3. The address of the first frame is configured in CCDC when application calls VIDIOC_STREAMON IOCTL.
4. As shown in **the above figure**, the first interrupt comes, when CCDC starts storing frame in the SDRAM.

5. Driver will configure address for the next frame in CCDC registers when interrupt for the first (bottom) field is received. For the even field interrupt, it just marks that capture is completed for the current frame.
6. After single frame capture interrupt, driver will get system time using jiffies timer. This time will be capture time for particular frame. Application can get this empty buffer with capture time by calling IOCtl with VIDIOC_DQBUF command.
7. If there is only single buffer in the incoming queue of the driver, driver will not update CCDC registers and CCDC will capture same frame until application calls VIDIOC_QBUF IOCtl. In the VIDIOC_QBUF IOCtl, driver will set the address of buffer to be queued in the CCDC registers if the buffer queue is empty and if the CCDC device is currently capturing the bottom field. Otherwise the buffer is queued. So when the next interrupt comes, buffer is already available to the device for capture. There is a restriction here. If application does not call VIDIOC_QBUF IOCtl after the buffer queue becomes empty and before the next interrupt, same frame will get captured i.e. frame drop will occur.

2.2.6.2 Output From Resizer (Data Flow Path 2)

Interrupt handling is concerned, this is similar to the case when data is output from CCDC. Driver needs to decide when to mark a frame buffer has completed capture and when to schedule next frame for capture.

RSZ_INT_DMA (for DM365) or (IPIPE_INT1_SDR) interrupt happens when the Resizer output image is written to SDRAM. So this interrupt handling is used to free up current frame buffer and schedule next frame buffer for capture. The buffer address is written to Resizer register as part of this interrupt handling. The assumption is that this interrupt will occur before next frame data arrive at the Resizer. vpfe_imp_dma_isr() is attached to handle this interrupt.

The current frame is marked as complete at VINT2 which is configured to occur at the end of the frame (height-1). vpfe_isr() is attached to INT2 interrupt handling/

3 Portability

3.1 Decoders

3.1.1 Data Structures and API for Decoder Interface

3.1.1.1 Decode Device Structure

```
/* decoder device structure */
struct decoder_device {
      u8  name[DECODER_MAX_NAME];
      vid_capture_interface_type if_type;
      int channel_id;
      u32 capabilities;
      int (*initialize) (void *dec);
      struct standard_ops *std_ops;
      struct control_ops *ctrl_ops;
      struct input_ops *input_ops;
      struct format_ops *fmt_ops;
      struct param_ops *params_ops;
      int (*deinitialize)(void *dec);
      int (*read_vbi_data)(struct v4l2_sliced_vbi_data, void *dec);
      int (*get_sliced_vbi_cap(struct v4l2_sliced_vbi_cap *cap,
           void *dec);
};
```

decoder_device

name	Name of decoder. For example, MT9T001
if_type	ORing of different interface types supported by this decoder. For example, INTERFACE_TYPE_BT656, INTERFACE_TYPE_BT1120, INTERFACE_TYPE_RAW, INTERFACE_TYPE_YCBCR_SYNC_8, INTERFACE_TYPE_YCBCR_SYNC_16, INTERFACE_TYPE_YCBCR_SYNC_10BIT.
channel_id	It indicates for which channel id, this decoder instance is used.
capabilities	It indicates VBI is supported or not.
Function Pointers	• Any new decoder needs to define certain functions, and store these function pointers in decoder_device structure. • VPFE keeps instance of decoder_device structure for each registered decoders. • VPFE will call these functions, as per requirement. • While calling, VPFE will pass pointer to respective decoder_device structure object. • VPFE gets this object at the time of decoder registration. Decoder will register itself to VPFE module at the time of module insertion.
initialize() function	This function will be called whenever decoder needs to be initialized. Its prototype is: int initialize(void *dec);
deinitialize() function	This function will be called whenever decoder needs to be deinitialized. Its prototype is: int deinitialize(void *dec);

3.1.1.2 Standard Ops Structure

```
/* standard ops structure */
struct standard_ops {
      int count;
      int (*enumstd)  (struct v4l2_standard * argp, void *dec);
      int (*querystd) (v4l2_std_id *argp, void *dec);
      int (*setstd)   (v4l2_std_id *argp, void *dec);
      int (*getstd)   (v4l2_std_id *argp, void *dec);
};
```

standard_ops

count	Indicates number of standard supported for particular decoder on particular channel.
enumstd()	This is the function for standard enumeration. (Described in Design section.)
querystd()	This is the function for standard detection. (Described in Design section.)
setstd()	This is the function for setting the standard. (Described in Design section.)
getstd()	This is the function for setting the standard. (Described in Design section.)

3.1.1.3 Control Ops Structure

```
/* control ops structure */
struct control_ops {
      int count;
      int (*queryctrl)  (struct v4l2_queryctrl *argp, void *dec);
      int (*setcontrol) (struct v4l2_control *argp, void *dec);
      int (*getcontrol) (struct v4l2_control *argp, void *dec);
};
```

control_ops

count	Indicates number of control supported for particular decoder on particular channel.
queryctrl()	This is the function for query control. (Described in Design section.) dec contains the pointer to decoder_device structure which points to the decoder instance of current channel. It takes v4l2_querycontrol instance as an output argument. It will validate passed control id, if it is valid one, it will filled information regarding that control into structure.
setcontrol()	This is the function for setting the particular control value. dec contains the pointer to decoder_device structure which points to the decoder instance of current channel. It takes v4l2_control instance as an input argument. It will validate passed control id and value, and if it is valid combination, will set the value in decoder.
getcontrol()	This is the function for getting the value for particular control. dec contains the pointer to decoder_device structure which points to the decoder instance of current channel. It takes v4l2_control instance as an output argument. It will validate passed control id, if it is valid, it will fill value for that control id in structure.

3.1.1.4 Input Ops Structure

```
/* input ops structure */
struct input_ops {
      int count;
      int (*enuminput) (struct v4l2_input * argp, void *dec);
      int (*setinput)  (int *argp, void *dec);
      int (*getinput)  (int *argp, void *dec);
};
```

input_ops

count	Indicates number of input supported for particular decoder on particular channel.
enuminput()	This is the function for input enumeration. dec contains the pointer to decoder_device structure which points to the decoder instance of current channel. It takes v4l2_input as an output argument. It contains index field, as per value of it, structure will be filled.
setinput()	This is the function for setting the input. dec contains the pointer to decoder_device structure which points to the decoder instance of current channel. It takes input index as an input argument and as per value of it; input will be set in decoder.
getinput()	This function will detect, input is present or not. dec contains the pointer to decoder_device structure which points to the decoder instance of current channel. It takes input index as an output argument and it will be filled with the current input value.

3.1.1.5 Format Ops Structure

```
/* format ops structure */
struct format_ops {
      int count;
      int (*enumformat) (struct v4l2_fmtdesc *argp, void *dec);
      int (*tryformat)  (struct v4l2_format *argp, void *dec);
      int (*setformat)  (struct v4l2_format *argp, void *dec);
      int (*getformat)  (struct v4l2_format *argp, void *dec);
};
```

format_ops

count	Indicates number of format supported for particular decoder on particular channel.
enumformat()	This is the function for format enumeration. dec contains the pointer to decoder_device structure which points to the decoder instance of current channel. It takes v4l2_fmtdesc as an output argument and index is one of the fields of it. As per value of index, structure will be filled. Structure contains information like buffer type for the format, description string, and pixel format.
tryformat()	This is the function for trying the format, to check whether it is valid or not. dec contains the pointer to decoder_device structure which points to the decoder instance of current channel. It takes v4l2_format as an input argument. It will validate the passed value in structure.
setformat()	This is the function to set new format. dec contains the pointer to decoder_device structure which points to the decoder instance of current channel. It takes v4l2_format as an input argument. It will validate it and then set it as a current format.
getformat()	This is the function to get current format. dec contains the pointer to decoder_device structure which points to the decoder instance of current channel. It takes v4l2_format as an output argument. It will be filled with the current format values.

3.1.1.6 Parameter Ops Structure

```
/* Parameters ops structure */
struct param_ops {
      int (*setparams) (void *params, void *dec);
      int (*getparams) (void *params, void *dec);
};
```

param_ops

setparams()	It is to set device parameters. dec contains the pointer to decoder_device structure which points to the decoder instance of current channel.
getparams()	It is to get device parameters. dec contains the pointer to decoder_device structure which points to the decoder instance of current channel.

3.1.1.7 vpif_register_decoder Function

```
int vpif_register_decoder(struct decoder_device *decoder);
```

Decoder will call this function from module_entry function, at the time of module insertion. It will register itself to VPFE module.

3.1.1.8 vpif_unregister_decoder Function

```
int vpif_unregister_decoder(struct decoder_device *decoder);
```

Decoder will call this function from module_exit function, at the time of module insertion. It will unregister itself to VPFE module.

3.1.2 Supported Decoders

The following decoders are supported in this release:

- TVP5146 (driver module tvp514x.[ch])
- TVP7002 (driver module tvp7002.[ch]). Tested only on DM365.
- MT9T001/MT9T031 (driver module mt9t001.[ch])
- MT9P031 (driver module mt9p031.[ch])

All these drivers are developed using the decoder interface described earlier. The decoder specific commands (like std, input, param etc) are passed directly by VPFE capture driver to the currently active decoder.

3.1.3 Adding New Decoder Support

VPFE capture driver is made such that if new decoder needs to be supported, it can be done by implementing some standard functions. One common vid_decoder_if.h file is available describing the interface for new decoder. To develop a new decoder driver, use existing drivers (that is close enough to the driver being written) as template. To support a new decoder following additional changes required in addition to developing a decoder module.

- In ccdc_common.c timing information for different standards are defined. Each timing information is tagged by a name. So when adding new standards to the decoder, make sure to use an existing tag or if new, add it to this file as well. Update also #define CCDC_CH0_MAX_MODES.
- Make sure to use appropriate interface type. If existing interface types are re-used, then it might work with out any change. VPFE Capture driver reads the interface type from the decoder and pass it to CCDC for configuration. Current driver has tested BT.656, BT.1120 and Raw capture interfaces. If a different interface is to be configured, check the ccdc_xxx.c (xxx refers to SoC, example ccdc_dm355.c for DM355) module, configure() function to verify if the required settings in CCDC is done for the interface being used.
- Currently davinci_vpfe.h defines Maximum number of decoders supported as 5. (#define VPFE_CAPTURE_NUM_DECODERS 5). For a specific system, if one or more decoder is not used, the same can be compiled out using configuration variable available for the decoder. Remember to change the above constant if number of decoders in the system crosses 5.
- Define decoder type constant in davinci_vpfe.h and add it to vpfe_open() and vpfe_init() functions in davinci_vpfe.c

4 User Interface

4.1 API

VPFE capture driver is a V4L2 device. Please refer V4L2 specification for the details of IOCTL calls. Please refer the design section for the IOCTL calls supported.

4.2 Data Structures

4.2.1 CCDC Configuration

VPFE Capture driver provides VPFE_CMD_S_CCDC_PARAMS to set CCDC configuration and VPFE_CMD_G_CCDC_PARAMS to get CCDC configuration. Driver calls setparams() at the ccdc hw interface to pass the parameters to CCDC module and calls getparams() to get the parameters. Old IOCTLS, VPFE_CMD_CONFIG_CCDC_RAW & VPFE_CMD_CONFIG_CCDC_YCBCR are supported for backward compatibility.

Application includes ccdc_xxx.h (example ccdc_davinci.c for DM6446, ccdc_dm355.c for DM355 and so on) if it needs to configure CCDC. Usually this is required only for Raw bayer capture to enable and configure CCDC modules such as Defect Pixel Correction, A-Law compression, Color Space Conversion etc. For YCbCr capture standard v4l2 Ioctls suffice.

Following high level data structures are used by application to configure CCDC:-

```
struct ccdc_config_params_raw {
      /* fields of this structure varies from SoC to SoC.
       * check the respective ccdc header file for details.
       */
};
```

Following structure used for YCbCr capture.

```
struct ccdc_params_ycbcr {
      /* fields of this structure varies from SoC to SoC.
       * check the respective ccdc header file for details.
       */
};
```

Support for following CCDC pre-processing modules are available on DM365. These modules can be configured through the above IOCTL call.

- Defect Pixel Correction
- Color Space Conversion
- Linearization
- Culling
- A-Law and DPCM compression
- Black Clamp

4.2.2 CCDC Control

Following control IDs (defined in davinci_vpfe.h) are available for CCDC control Ioctls:

- VPFE_CCDC_CID_R_GAIN – Adjustment of Gain for R
- VPFE_CCDC_CID_GR_GAIN – Adjustment of Gain for Gr
- VPFE_CCDC_CID_GB_GAIN – Adjustment of Gain for Gb
- VPFE_CCDC_CID_B_GAIN – Adjustment of Gain for B
- VPFE_CCDC_CID_OFFSET – Offset adjustment

4.2.3 MT9T001 Parameter Structure

```
include file is mt9t001.h

struct mt9t001_params {
      v4l2_std_id std;
      int inputidx;
      struct mt9t001_format_params format;
      struct mt9t001_rgb_gain rgb_gain;
      struct mt9t001_black_level_calibration black_calib;
};
```

Fields

std	Standard of MT9T001
inputidx	Index of input of MT9T001 device
format	Standard specific MT9T001 parameters. See mt9001.h for details.
rgb_gain	RGB gain parameters. See mt9001.h for details.
black_calib	Black level calibration value. See mt9001.h for details.

4.2.4 MT9P031 Parameter Structure

```
include file is mt9p031.h

struct mt9p031_params {
      v4l2_std_id std;
      int inputidx;
      struct mt9p031_format_params format;
      struct mt9p031_rgb_gain rgb_gain;
      struct mt9p031_test_pat test_pat;
      struct mt9p031_misc_cfg misc_cfg;
};
```

Fields

std	Standard of MT9P031
inputidx	Index of input of MT9P031 device
format	Standard specific MT9T001 parameters. See mt9p031.h for details.
rgb_gain	RGB gain parameters. See mt9p031.h for details.
test_pat	Test pattern to replace real image data. See mt9p031.h for details.
misc_cfg	Miscellaneous parameters. See mt9p031.h for details.

4.2.5 TVP5146 Parameter Structure

```
include file is tvp514x.h

struct tvp514x_params {
      v4l2_std_id std;
      int inputidx;
      struct v4l2_format fmt;
};
```

Fields

std	Standard of TVP5146
inputidx	Index of input of TVP5146 device
fmt	VBI format (not supported in VPFE Capture driver)

4.2.6 TVP7002 Parameter Structure

```
include file is tvp7002.h

struct tvp7002_params {
      v4l2_std_id std;
      int inputidx;
      struct alc_filter alc;
      struct tvp7002_gain gain;
      struct tvp7002_offset offset;
      struct tvp7002_format_params format;
};
```

Fields

std	Standard of TVP7002
inputidx	Index of input of TVP7002 device
alc	ALC filter params. See tvp7002.h for details.
gain	Structure for gain information. See tvp7002.h for details.
offset	Structure for offset(brightness) information. See tvp7002.h for details.
format	Structure for tvp7002 format params.

4.2.7 Request Buffer Structure for V4L2

```
struct v4l2_requestbuffers
{
      __u32                 count;
      enum v4l2_buf_type    type;
      enum v4l2_memory      memory;
      __u32                 reserved[2];
};
```

Fields

count	Number of buffers requested
type	V4L2_BUF_TYPE_VIDEO_CAPTURE
memory	V4L2_MEMORY_MMAP or V4L2_MEMORY_USERPTR

4.2.8 Buffer Structure for V4L2

```
struct v4l2_buffer
{
      __u32                 index;
      enum v4l2_buf_type    type;
      __u32                 bytesused;
      __u32                 flags;
      enum v4l2_field       field;
      struct timeval        timestamp;
      struct v4l2_timecode  timecode;
      __u32                 sequence;

      /* memory location */
      enum v4l2_memory      memory;
      union {
            __u32           offset;
            unsigned long   userptr;
      } m;
      __u32                 length;
      __u32                 input;
      __u32                 reserved;
};
```

Relevant Fields for VPFE Capture Driver

index	Index of the buffer
type	Type of the data stream: V4L2_BUF_TYPE_VIDEO_CAPTURE
memory	V4L2_MEMORY_MMAP or V4L2_MEMORY_USERPTR
bytesused	The number of bytes occupied by the data in the buffer.
field	The field order of the image in the buffer
m.userptr	When memory is V4L2_MEMORY_USERPTR this is a pointer to the buffer in virtual memory, set by the application.
m.offset	When memory is V4L2_MEMORY_MMAP this is the offset of the buffer from the start of the device memory.
length	Size of the buffer

4.2.9 Query Capability Structure for V4L2

```
struct v4l2_capability
{
      __u8    driver[16];
      __u8    card[32];
      __u8    bus_info[32];
      __u32   version;
      __u32   capabilities;
      __u32   reserved[4];
};
```

Relevant Fields for VPFE Capture Driver

driver	ccdc capture
card	DaVinci EVM
bus_info	Platform
version	Version code for VPFE capture module
capabilities	V4L2_CAP_VIDEO_CAPTURE or V4L2_CAP_STREAMING

4.2.10 Input Structure for V4L2

```
struct v4l2_input
{
      __u32        index;
      __u8         name[32];
      __u32        type;
      __u32        audioset;
      __u32        tuner;
      v4l2_std_id  std;
      __u32        status;
      __u32        reserved[4];
};
```

Relevant Fields for VPFE Capture Driver

index	Index with value zero indicates first input type of first decoder that has been registered at the time of module insertion, and after possible inputs for first decoder, next index from application will be mapped to first input of second decoder, and so on. For example, if first registered decoder is TVP5146 and second is MT9T001, and both are supporting one type of input; then if application will pass 0 as an input index, it will enumerate input of TVP5146 and for input index 1, it will enumerate input of MT9T001.
name	Name of video input
std	Every video input supports one or more different video standards. This field is a set of all supported standards.

4.2.11 Standard Structure for V4L2

```
struct v4l2_standard
{
      __u32              index;
      v4l2_std_id        id;
      __u8               name[24];
      struct v4l2_fract  frameperiod; /* Frames, not fields */
      __u32              framelines;
      __u32              reserved[4];
};
typedef __u64 v4l2_std_id;
struct v4l2_fract {
      __u32   numerator;
      __u32   denominator;
};
```

Relevant Fields for VPFE Capture Driver

index	Index of the supported standards
id	Standard id. Supported standards are mentioned in enumerations and define section.
name	Name of the standard
frameperiod.numerator	Numerator value to set particular frame rate for standard.
frameperiod.denominator	Denominator value to set particular frame rate for standard.
framelines	Total lines per frame including blanking.

4.2.12 Format Description Structure for V4L2

```
struct v4l2_fmtdesc
{
      __u32               index;            /* Format number      */
      enum v4l2_buf_type  type;             /* buffer type        */
      __u32               flags;
      __u8                description[32];  /* Description string */
      __u32               pixelformat;      /* Format fourcc      */
      __u32               reserved[4];
};
```

Relevant Fields for VPFE Capture Driver

index	Index of the supported formats
type	Type of the data stream: V4L2_BUF_TYPE_VIDEO_CAPTURE.
description	Description of the format, a NUL-terminated ASCII string. This information is intended for the user.
pixelformat	The image format identifier.

4.2.13 Format Structure for V4L2

```
struct v4l2_format
{
      enum v4l2_buf_type type;
      union
      {
            struct v4l2_pix_format  pix;
            struct v4l2_window      win;
            struct v4l2_vbi_format  vbi;
      } fmt;
};
struct v4l2_pix_format
{
      __u32                   width;
      __u32                   height;
      __u32                   pixelformat;
      enum v4l2_field         field;
      __u32                   bytesperline;
      __u32                   sizeimage;
        enum v4l2_colorspace  colorspace;
      __u32                   priv;
};
```

Relevant Fields for VPFE Capture Driver

type	Type of the data stream: V4L2_BUF_TYPE_VIDEO_CAPTURE.
fmt.pix.pixelformat	The pixel format
fmt.pix.field	The field order of the image in the buffer
fmt.pix.bytesperline	Distance in bytes between the leftmost pixels in two adjacent lines.
fmt.pix.sizeimage	Size in bytes of the buffer to hold a complete image, set by the driver.

4.2.14 Query Control Structure for V4L2

```
struct v4l2_queryctrl
{
      __u32                id;
      enum v4l2_ctrl_type  type;
      __u8                 name[32];   /* Whatever */
      __s32                minimum;    /* Note signedness */
      __s32                maximum;
      __s32                step;
      __s32                default_value;
      __u32                flags;
      __u32                reserved[2];
};
```

Relevant Fields for VPFE Capture Driver

id	Identifies the control, set by the application.
type	Type of control: V4L2_CTRL_TYPE_INTEGER, V4L2_CTRL_TYPE_BOOLEAN etc.
name	Name of control.
minimum	Minimum value, inclusive. It is signed.
maximum	Maximum value, inclusive. It is signed.
default_value	The default value of the control.

4.2.15 Control Structure for V4L2

```
struct v4l2_control
{
      __u32      id;
      __s32      value;
};
```

Relevant Fields for VPFE Capture Driver

id	Identifies the control, set by the application.
value	Value for corresponding control.

4.3 Enumerations and Defines

4.3.1 Possible Standards for Different Decoders

Use respective header files.

MT9T001

```
#define V4L2_STD_MT9T001_VGA_30FPS
#define V4L2_STD_MT9T001_480p_30FPS
#define V4L2_STD_MT9T001_576p_25FPS
#define V4L2_STD_MT9T001_720p_30FPS
#define V4L2_STD_MT9T001_1080p_18FPS
#define V4L2_STD_MT9T001_QXGA_12FPS
```

MT9P031

```
#define V4L2_STD_MT9P031_VGA_30FPS
#define V4L2_STD_MT9P031_480p_30FPS
#define V4L2_STD_MT9P031_576p_25FPS
#define V4L2_STD_MT9P031_720p_30FPS
#define V4L2_STD_MT9P031_720p_60FPS
#define V4L2_STD_MT9P031_960p_30FPS
#define V4L2_STD_MT9P031_1080p_30FPS
#define V4L2_STD_MT9P031_1080p_25FPS
#define V4L2_STD_MT9P031_SXGA_30FPS
#define V4L2_STD_MT9P031_UXGA_30FPS
#define V4L2_STD_MT9P031_QXGA_15FPS
```

TVP5146

```
#define V4L2_STD_525_60
#define V4L2_STD_625_50
#define VPFE_STD_AUTO
#define VPFE_STD_625_50_SQP
#define VPFE_STD_525_60_SQP
#define VPFE_STD_AUTO_SQP
```

TVP7002

```
#define V4L2_STD_720P_60
#define V4L2_STD_1080I_60
```

5 Driver Files

Table 3 lists the files for the VPFE Capture driver.

Table 3. VPFE Capture Driver Files

Filename	Location in Linux Tree	Description
davinci_vpfe.c	drivers/media/video/davinci/	VPFE capture driver (bridge driver)
ccdc_davinci.c	drivers/media/video/davinci/	CCDC module for DM6446
ccdc_dm355.c	drivers/media/video/davinci/	CCDC module for DM355
ccdc_dm365.c	drivers/media/video/davinci/	CCDC module for DM365
ccdc_common.c	drivers/media/video/davinci/	Modules that provide timing information for configuring CCDC for a specific standard.
mt9t001.c	drivers/media/video/davinci/	Decoder module for MT9T001/MT9T031
mt9p031.c	drivers/media/video/davinci/	Decoder module for MT9P031
tvp514x.c	drivers/media/video/davinci/	Decoder module for TVP5146. Can support TVP5147 as well.
tvp7002.c	drivers/media/video/davinci/	Decoder module for TVP7002
davinci_vpfe.h	include/media/davinci/	Header file for VPFE Capture driver
ccdc_hw_if.h	include/media/davinci/	Interface for CCDC module configuration
ccdc_davinci.h, ccdc_dm355.h, ccdc_dm365.h	include/media/davinci/	Header files required to configure CCDC from application
ccdc_common.h	include/media/davinci/	Types for CCDC timing information
vpfe_types.h	include/media/davinci/	vpfe types definitions
mt9t001.h	include/media/davinci/	Header file to include MT9T001/31-specific standards and structures
mt9p031.h	include/media/davinci/	Header file to include MT9P03131-specific standards and structures
tvp5146.h	include/media/davinci/	Header file to include TVP51476-specific standards and structures
tvp7002.h	include/media/davinci/	Header file to include TVP7002-specific standards and structures

6 Build and Installation

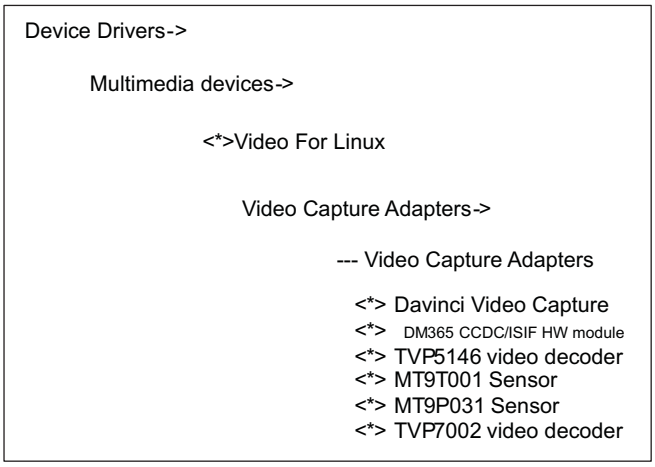
6.1 Build Steps

Access to the VPFE capture is provided through the /dev/video0 device file.

Following steps describe the procedure to build VPFE capture drivers as static modules in Kernel:

Use menuconfig to navigate Kconfig tree to Video Capture Adapters menu as shown in Figure 6. Use the space bar to select the driver to be built as a static module (indicated by *).

Figure 6. VPFE Capture Drivers Selection as a Static Module

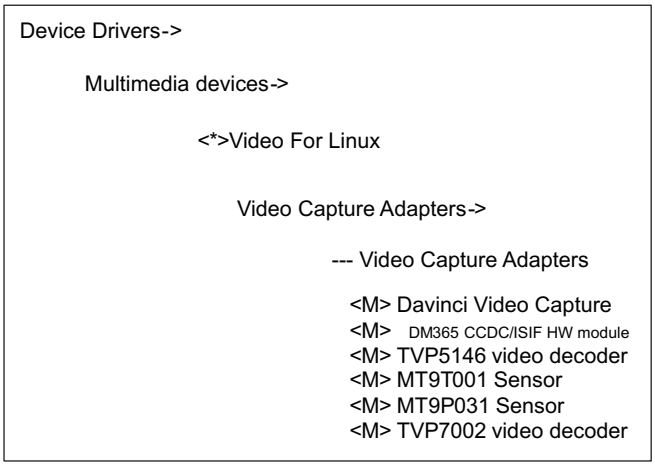


This enables VPFE Capture driver Support in kernel. Now build kernel image.

Following steps describe the procedure to build VPFE capture drivers as dynamic modules. \

Use menuconfig to navigate Kconfig tree to Video Capture Adapters menu as shown in Figure 7. Use the space bar to select the driver to be built as a dynamic module (indicated by M). Save the configuration and build the kernel image. Once this is complete, build the drivers using the make modules command.

Figure 7. VPFE Capture Drivers Selection as a Dynamic Module



6.2 Installation

The module parameters referred here can be applied as Kernel boot argument as well by adding a davinci_capture. prefix to it (for example, davinci_capture.device_type=1). To use continuous mode, apply following boot argument / module parameter for image processing (imp) module (depending on how the module is built into the kernel image).

For DM355

dm355_imp.oper_mode=0

For DM365

dm365_imp.oper_mode=0

Following examples show dynamic insertion and removal of VPFE Capture Device Driver.

```
>insmod davinci_capture_driver.ko device_type=0 channel0_numbuffers=3 channel0_bufsize=691200
```

In the above,

device_type = 0	→ Mt0T001 is the default decoder.
device_type = 1	→ TVP5146 is the default decoder.
device_type = 2	→ MT9T031 is the default decoder.
device_type = 3	→ MT0P031 is the default decoder.
device_type = 4	→ TVP7002 is the default decoder.
channel0_numbuffers = 0	→ Driver buffer count is zero.
1 <= Numbuffers <= 3	→ Three driver buffers are allocated. Use this when the USERPTR buffer exchange mechanism is used so that buffers are not pre-allocated in the driver.
3 < Numbuffers	→ Allocated driver buffer count is numbuffers.
If channel#_numbuffers is not specified, three driver buffers are allocated.	

To remove the module, use this command:

```
>rmmod davinci_capture_driver
```

To insert/remove ccdc module, use this command:

```
>insmod ccdc_common.ko
>insmod ccdc_xxx.ko (where xxx stands for davinci or dm355 or dm365)
>rmmod ccdc_xxx
>rmmod ccdc_common
```

To insert/remove TVP514x module, use this command:

```
>insmod tvp514x.ko
>rmmod tvp514x
```

To insert/remove TVP7002 module, use this command:

```
>insmod tvp7002.ko
>rmmod tvp7002
```

To insert/remove MT9T001 module, use this command:

```
>insmod mt9t001.ko
>rmmod mt9t001
```

To insert/remove MT9P031 module, use this command:

```
>insmod mt9p031.ko
>rmmod mt9p031
```

Module initialization order

If ipipe modules are built as dynamic, do insmod of the modules prior to below steps.

Insmod order

1. insmod ccdc_common.ko
2. insmod ccdc_dm365.ko (use platform specific module here)
3. insmod davinci_capture.ko device_type=1
4. insmod mt9t001.ko
5. insmod mt9p031.ko
6. insmod tvp514x.ko
7. insmod tvp7002.ko

Do rmmod in the reverse order.

7 Example Applications

Please refer the readme.txt files under v4l2 and previewer_resizer folder of example directory for sample applications. v4l2 shows video capture and display using vpfe capture driver and davinci display driver. previewer_resizer folder shows examples for doing capture, preview , resize and display in single shot as well as continuous (on the fly) mode of operation of the image processing block.